Modeling and Development of Superconducting Nanowire Single Photon Detectors

Completed Technology Project (2016 - 2020)

Project Introduction

This proposal outlines a research project as the central component of a Ph.D. program focused on the device physics of superconducting nanowire single photon detectors (SNSPDs). This program would be carried out by a profile 4 candidate at the California Institute of Technology in collaboration with the JPL and seeks 3.5 years of fellowship support. The research of this proposal aims to use a balance of theory, simulation, and experimental methods to investigate the underlying device physics of SNSPDs. SNSPDs are a recently developed class of optical detector with single photon sensitivity and impressive performance characteristics including high count rates, high efficiency, and low dark count rates. Despite the rapid progress in their development since their first demonstration fifteen years ago, the specific details of certain aspects of their operation are a topic of discussion in the literature. In particular, the detection mechanism of SNSPDs and the evolution of quasiparticles within a hotspot are not fully understood. Through first principles modeling and corresponding experimental validation, this research aims to expand the current knowledge of both engineering related design challenges and the fundamental physics that dictates SNSPD behavior. Initial investigations into the hotspot evolution within amorphous superconductors and heat dissipation within these devices are expected to yield design criteria for optimizing SNSPD arrays. These initial questions will lead to a more fundamental analysis of the dynamics of quasiparticles within a superconductor which are expected to provide the knowledge necessary to design higher performance SNSPDs. JPL is currently developing 64-pixel SNSPD arrays for use as the ground receiver of tests of deep space optical communication (DSOC) links. This research project would provide an opportunity to research this device physics in a level of detail not practical for the JPL team, while providing feedback that can improve the performance of this crucial space technology. This makes the work directly relevant for TABS Element 5.1.1 (optical communication detector development) while carrying out the investigation in a way both not practical for the current NASA team and substantial enough to be a Ph.D. project.

Anticipated Benefits

JPL is currently developing 64-pixel SNSPD arrays for use as the ground receiver of tests of deep space optical communication (DSOC) links. This research project would provide an opportunity to research this device physics in a level of detail not practical for the JPL team, while providing feedback that can improve the performance of this crucial space technology.

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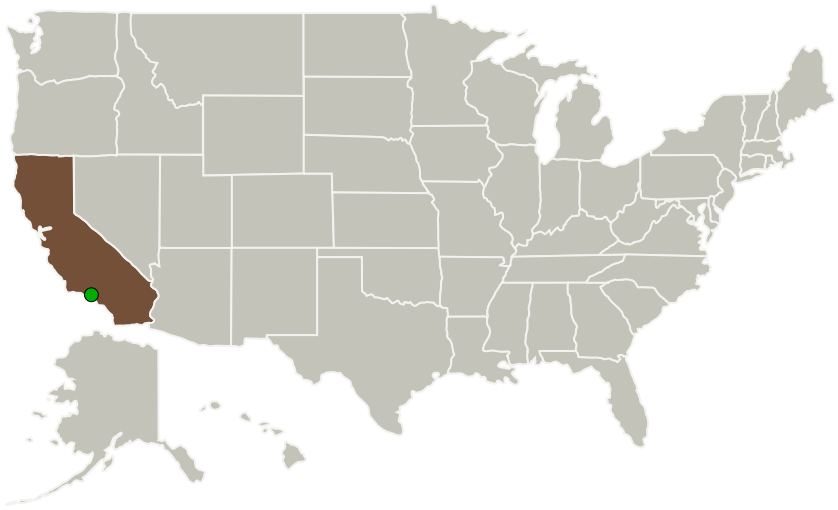
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology(CalTech)	Lead Organization	Academia	Pasadena, California
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations
California

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

California Institute of Technology (CalTech)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Keith Schwab

Co-Investigator:

Jason P Allmaras

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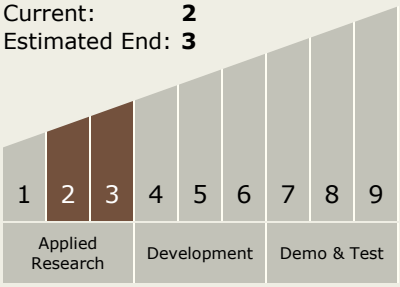
Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX05 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems
  - TX05.1 Optical Communications
    - TX05.1.1 Detector Development

Target Destinations

Earth, The Moon, Others Inside the Solar System